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BOTANY.—*Accessory vascular bundles in* Murraya koenigii *(Linn.) Spreng. (Rutaceae: Aurantioideae).*[1] Frank D. Venning, University of Miami. (Communicated by Walter T. Swingle.)

From time to time plant anatomists have reported the presence of "accessory," "free" or "unattached" vascular bundles in various floral parts of several plant families. Varying amounts of significance have been given them by investigators. Unattached bundles, which are amphiphloic, or concentric, are described by Arber (*1*) as occurring in the genera *Lunaria, Sisymbrium,* and *Raphanus* and are figured in petals of *Lunaria,* stamens of *Sisymbrium,* and ovule of *Raphanus.* These bundles are described as passing through an amphiphloic stage, finally becoming collateral by the time the petals are free.

Considerable study has been given the various members of the subfamily Aurantioideae in regard to the vascular systems of their flowers. Tillson and Bamford (*2*) studied the floral vascular anatomy of 94 species belonging to 29 genera of the Aurantioideae. They make no mention of accessory bundles in any of the genera or species they studied. Their observations showed that in the genus *Murraya,* including *M. koenigii,* the vascular bundles supplying the various floral parts arose individually from the central cylinder of vascular tissue in the pedicel and that there was no exchange of lateral branch bundles between floral parts.

Accessory bundles were mentioned as occurring in the flowers of the Eureka Lemon, a cultivated variety of *Citrus limon,* by Ford (*3*), and are described as several groups of small vascular traces below the sepals.

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"Some of these are not attached below, but others diverge from the vascular cylinder about 3 mm below the bases of the sepals." Ford found that all these bundles extended into the lateral part of the sepals and called them accessory sepal traces. He noted that the provascular elements for these accessory traces are present as early in ontogeny as those of the other bundles of the receptacle and that those attached to the main dorsal sepal traces diverge from them while they are yet a part of the stele.

In connection with an anatomical study of the two commonly cultivated species of *Murraya*, *M. koenigii* and *M. paniculata*, it was found that one of the species, *M. paniculata*, had no accessory bundles, but both loose and attached accessory bundles were found in *M. koenigii*, as shown in this paper.

MATERIALS AND METHODS

The flowers of *M. koenigii* are small and white and are borne in terminal corymbs; sepals free, five in number, about 1 mm long; petals 4–6 mm long, five in number; ten stamens, the alternate ones shorter; the ovary, borne on a short cylindrical disk, is 2- or 3-celled. Flower buds, flowers, and young and mature fruits were collected principally from a large heavily flowering tree growing in Dr. David Fairchild's Kampong in Coconut Grove, Fla. This tree is described and figured by Swingle (*4*). The material was fixed in Formalin-Aceto-Alcohol and imbedded in paraffin. Cross and longitudinal serial sections were cut 10 microns thick and stained with a safranine and fast green staining combination.

OBSERVATIONS

In the pedicel below the base of the sepals, the vascular elements form a continuous cylinder of tissue enclosing the pith. As is the case with many woody stems, the xylem borders the pith on the inside of the stele, and the phloem elements are on the outside; these two tissues are separated by the vascular cambium. On the outside of the phloem a cylinder of elongated parenchyma cells, several cells in thickness, makes up the pericycle. Before and during flowering no lignification of the pericycle occurs, but during the development of the fruit many of these cells become sclerenchymatous fibers.

In the receptacle, bundles of vascular tissue diverge from the stele to supply the various floral parts. The five sepal bundles are the first of such bundles to diverge. These gradually ascend upward and outward away from the stele across the receptacle and then follow a lateral course at the base of the sepals, eventually forming the sepal midribs. As these five relatively large midrib bundles diverge, five bundle trace gaps are apparent in the stele. Just above the point where the sepal midribs begin to separate from the stele, and outside of the pericycle in the cortical parenchyma, the basal limits of loose accessory bundles may appear (Fig. 1), usually as one or two vertical annular vessels in the cortical parenchyma. These vessels are much smaller in diameter than the surrounding cortical parenchyma cells and are spaced approximately halfway between any two diverging sepal midrib bundles. When present their basal ends are always in this relative position in the receptacle.

The course of the unattached bundles is parallel to that of the main sepal bundles across the receptacle, extending upward and gradually outward about halfway across the cortex until on a level with the sepal base. Here they show a lateral course, and extend out into the sepal after branching one or more times. Some branches terminate in the receptacle near the sepal base; others extend to the lower outer edge of the sepal, these usually terminate near an oil gland (Fig. 2).

In mature flowers the largest number of xylem elements occurs in the bundles just as they begin to extend laterally from near the center of the cortex to the sepals. The elements at this point consist of two to four annular vessels and eight to ten spiral vessels, which are identical in appearance with the annular and spiral vessels of the primary xylem in the stele. From here downward the number diminishes rather rapidly, until at the lower end only one or two vessels can be observed; these are always annular in nature, spiral vessels appear higher up in the bundle. Directly below the lowest xylem a few elongated parenchyma cells are sometimes present; these extend downward directly beneath the last lignified vessel for 10 or 20 microns. Under-

neath these there are no evidences of provascular parenchyma, only the large, isodiametric cortical parenchyma cells.

In the portion of the bundle extending laterally the width in every case gradually diminished as the sepal base was ap-

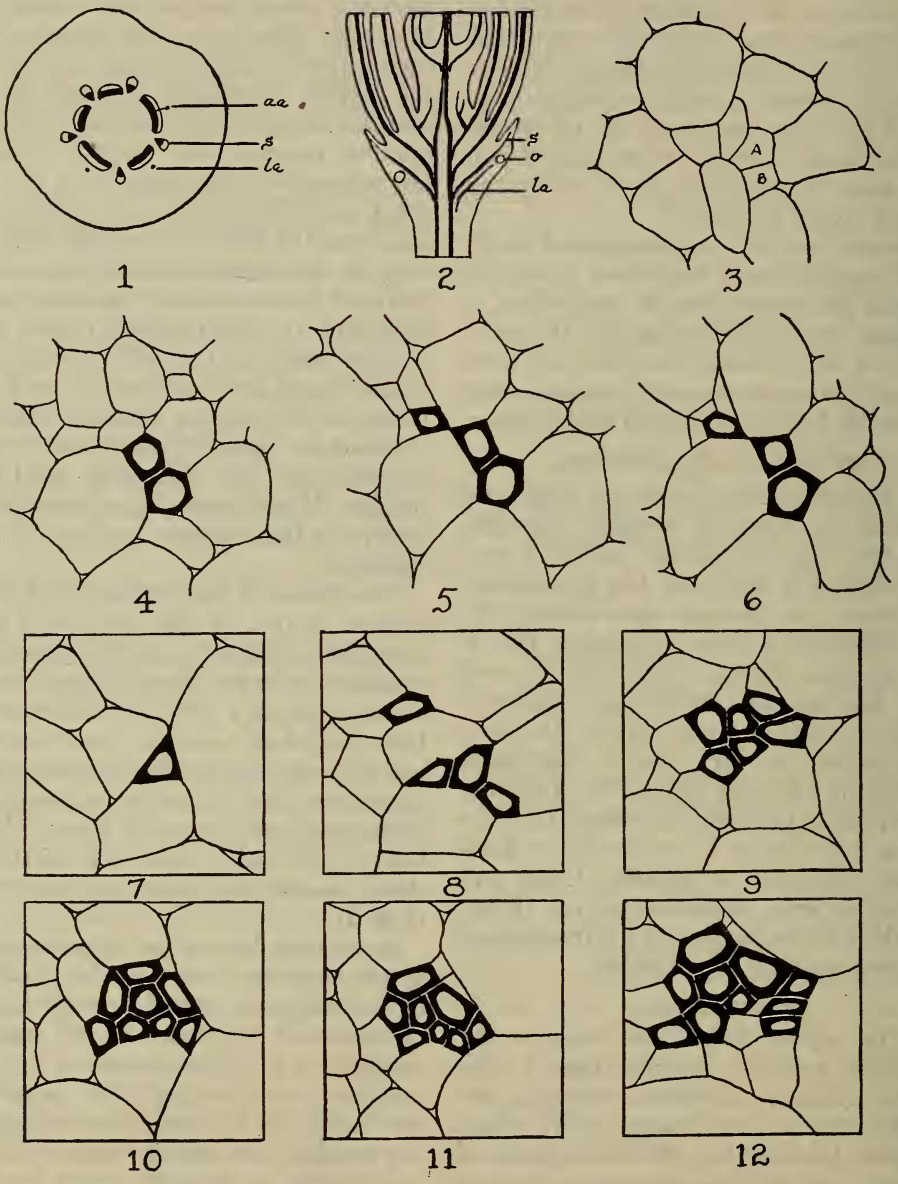

Fig. 1.—Diagram of cross section of the base of a flower at the point of origin of the accessory bundles: *aa*, attached accessory bundle; *s*, sepal midrib bundle; *la*, loose accessory bundle. Fig. 2.—Diagrammatic longitudinal view of base of a flower, showing position of a loose accessory bundle in relation to the main vascular system and floral parts: *s*, sepal midrib bundle; *o*, oil gland; *la*, loose accessory bundle. Fig. 3.—Arrangement of parenchyma cells 10μ beneath the lower limit of the loose accessory bundle shown in Fig. 4; cells A and B are elongated parenchyma cells beneath the two xylem elements shown in Fig. 4. Figs. 4–6.—Three successive sections 10μ apart of the basal portion of a loose accessory bundle. Figs. 7–12.—Six successive sections 10μ apart of the basal portion of a loose accessory bundle, showing the progressive increase in the number of xylem elements as the bundle ascends. (Fig. 1, ×30; Fig. 2, ×12; Figs. 3–12, ×550. Figs. 4–6 are from slides S. & V. 57 B, Figs. 7–12 from slides S. & V. 57 I, in Univ. Miami Tropical Botany Histological Research Collection.)

proached. At this extremity not all the cells composing the bundles had become lignified, but these proxylem cells were easily distinguished from those of the cortical parenchyma, as they had very small diameters, dense cytoplasm, and were more elongate. The average length of 23 such bundles from their first appearance in the cortex to their ultimate termination was 0.475 mm.

Although xylem was well differentiated in the loose accessory bundles, no phloem or phloem parenchyma was observed in connection with them in *Murraya koenigii*. It is true that a few small parenchyma cells often exist in conjunction with the xylem in the large portion of the loose bundles, but near the basal portion of the bundles these cells were often lacking, and they were never numerous. Although smaller than most cells of the cortical parenchyma, they do not show the cell shape or elongation of the protophloem and metaphloem parenchyma of the stele, and of course they have no sieve plates. Rather, they seem to be small, irregularly isodiametric cortical parenchyma cells.

In addition to the loose accessory bundles some flowers have accessory bundles attached to the main vascular system. These appear in the receptacle at the same level as the lower limits of the loose bundles, but are connected with the vascular elements of the stele which form the petal midribs higher up in the receptacle. These attached bundles extend laterally across the cortex to the sepal bases, but describe a much shorter, flatter arc than the loose bundles, their average length being only 0.220 mm, or about half that of the loose bundles. Structurally they are similar to the loose accessory bundles, being composed of annular and spiral vessels, and apparently also lack phloem. The greatest number of elements in any one bundle occurs at a point about equidistant from the ends, and diminishes to only a few xylem elements at each end. At the base only three or four xylem elements are attached to the petal midrib.

Attached accessory bundles are not always present in any given flower, and no more than two attached accessory bundles were observed in any one of 22 flowers studied. Data concerning these flowers are listed in Table 1. It has not been determined whether the attached accessory bundles are branches of the petal midrib or bundles that arise independently and later continue to differentiate downward, ultimately connecting with the xylem of the stele. Studies of these bundles in young flower buds suggest this latter concept.

Table 1.—Occurrence of Accessory Bundles in 22 Flowers of Murraya koenigii

Total accessory bundles per flower	Number of loose accessory bundles	Number of attached accessory bundles
0	—	—
0	—	—
1	1	—
1	1	—
1	1	—
2	—	2
2	1	1
2	1	1
2	1	1
2	2	—
2	2	—
2	2	—
2	2	—
2	2	—
2	2	—
2	2	—
3	2	1
3	3	—
3	3	—
4	3	1
4	4	—
5	5	—

The calyx is persistent after abscission of the petals and stamens and remains fresh and green during the development of the fruit. The calyx has reached its maturity when the petals and stamens are abscissed from the flower, as sections of the basal portions of mature fruits show its dimensions are no larger than they were in mature flowers. The loose and attached accessory bundles were no larger in these sections than in those of mature flowers; evidently they reach their maximum growth at the same time as the calyx.

The irregular occurrence of both the loose and attached accessory bundles in any given flower can not as yet be explained. It seems to have no relation to the position of the flower on the large much-branched terminal corymb, and no other features of the floral anatomy seem to be correlated with their occurrence or nonoccurrence.

Preliminary studies of serial microtome sections of flowers of other species of the Aurantioideae have shown that loose or attached accessory bundles or both occur in 16 species in both of the tribes 4 of the 6 subtribes, and 8 genera. These bundles show great diversity in structure, course, and branching from those described for *M. koenigii*. On the other hand, a very thorough study of several other species of the Aurantioideae has not disclosed a single accessory bundle.

SUMMARY

Although the vascular anatomy of the orange subfamily has been under study for over three-quarters of a century, Ford (*3*) was the first person to mention the presence of accessory bundles, which he described in the lemon. The present paper describes loose and attached accessory bundles which occur in the receptacle and calyx of *Murraya koenigii* and discusses their histology and relation to the main vascular system. It is pointed out that accessory vascular bundles are of widespread occurrence in the flowers of many other members of the subfamily Aurantioideae.

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ENTOMOLOGY.—*Concerning Neotropical Tingitidae (Hemiptera).*[1] C. J. Drake and E. J. Hambleton.

The present paper contains notes on 57 species of Neotropical Tingitidae, including the descriptions of two new genera and 22 new species. The types are in the Drake collection. The collections were made by E. J. Hambleton.

Family PIESMIDAE

Piesma cinerea (Say)

Los Cerritos, Guatemala, 18 specimens, taken on *Amaranthus*, July 5, 1944. This species is widely distributed, ranging from Canada south into Argentina.

Family TINGITIDAE

Subfamily Cantacaderinae

Phatnoma annulipes Champion

Turrialba, Costa Rica, 2 specimens, on *Vernonia* sp., August 13, 1944.

Subfamily Tingitinae

Monanthia c-nigrum Champion

El Porvenir, Guatemala, 7 specimens, July 9, 1944.

Monanthia loricata Distant

Villavicencio, Colombia, 50 specimens, November 3, 1944.

Monanthia berryi Drake

Machala, Ecuador, 14 specimens, Sept. 27, 1944. Recorded in the literature from Peru.

Monanthia monotropidia Stål

Tingo María, Peru, 3 specimens, September 14, 1944. Villavicencio, Colombia, 5 specimens, November 3, 1944, and San Andrés, El Salvador, 1 specimen, July 21, 1944.

Monanthia senta Drake and Hambleton

Salinas, Ecuador, 12 specimens, October 14, 1944; Machala, Ecuador, 6 specimens, September 27, 1944.

Monanthia pucallpana, n. sp.

Head black, shining, with five rather short, forward-directed, testaceous spines; eyes black. Antennae moderately long, indistinctly pilose; segment I short, slightly thickened, reddish brown; II slightly slenderer, reddish; III very slender, testaceous, about two and one-half times as long as IV; IV clavate, hairy. Bucculae broad, reticulated, closed in front. Rostrum moderately long, yellowish brown, extending to middle coxae. Legs moderately long, ferrugineous, the tibiae testaceous, the tarsi dark. Body beneath black.

[1] Received May 15, 1945.